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A LABORATORY EVALUATION OF CONCRETE SURFACE SEALANTS

MATERIALS INFORMATION
ENGINEERING MATERIALS OFFICE

A LABORATORY EVALUATION

OF

CONCRETE SURFACE SEALANTS

by

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MINISTRY OF TRANSPORTATION AND COMMUNICATIONS
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SUMMARY

Ten concrete surface sealants were evaluated for their effectiveness in increasing the resistance of concrete to penetration by water and chloride ions, and to salt scaling. The treated concrete was also tested for moisture vapour permeability. All tests were carried out using concretes with low and normal air contents.

Of the ten sealants tested, three penetrants and three coatings were found to perform adequately in the laboratory tests. The three penetrants and one of the coatings performed well in all the tests including the moisture vapour permeability. The other two coatings failed the moisture vapour permeability tests thus they are recommended only for applications where moisture vapour can escape through other unsealed surfaces.

The report lists instances when the use of concrete surface sealants would be justified.

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INTRODUCTION

Freezing conditions and the use of deicing salt on highways cause two types of concrete distress. Spalling occurs when salt penetrates the concrete down to the reinforcing steel causing corrosion of the steel. Scaling is the disintegration of the actual concrete surface. The two types of distress manifest themselves mainly in bridge decks, parapet walls, barrier walls, retaining walls, abutments, piers and columns. Sidewalks and curbs do not contain reinforcing steel so they are vulnerable only to surface scaling.

Neither of the two types of distress occur where the concrete is well air entrained, its water-cement ratio is not excessive, the reinforcing steel is epoxy coated and there is an adequate concrete cover to the steel. However, where for any reason one of the above requirements is not satisfied, a surface treatment may be desirable to prevent the penetration of deicing salt.

Treatment consists of an application of a concrete surface sealant. There are two types of sealants; coatings and penetrants. The first forms a film on the surface and usually causes at least some discolouration. The latter penetrates the concrete and causes no discolouration.

There are many concrete coatings and penetrants available on the market in Ontario. However, it is difficult to select a suitable product without testing it to be reasonably sure that it will perform adequately. To evaluate the effectiveness of these products a laboratory testing program was carried out during September 1984 - March 1985. The evaluation and its results are presented herein.

SEALANTS TESTED

Ten proprietary sealants were included in the project. Each of them was tested for its non-volatile content, relative density and viscosity, and most of them for pH value. Table A lists the sealants and their chemical type and physical characteristics.

The non-volatile contents were determined on 10 g samples dried overnight at 105 ^{o}C. The relative densities were determined at 25^{o}C with a Westphal balance. The viscosities were obtained with a Gardner Bubble Viscosimeter at 25^{o}C. The pH values were determined by shaking 50 mL of the sealant with 50 mL of distilled water and reading the pH of the aqueous extract.

It was impossible to determine pH value of E.A. Sealer and Dekguard (top coat) as these materials formed "stubborn" emulsions with water that could not be separated.

The non-volatile contents of Cap Seal X, Chemtrete, Preco Silane and Thueco 161 are substantially lower than those quoted by their manufacturers. One of the manufacturers has explained that these are silane sealants which polymerize when they penetrate concrete and this results in a higher solids content.

TABLE A CHARACTERISTICS OF THE SEALANTS TESTED

Sealant	Type	pH	Non-volatile content, % by mass	Relative Density	Viscosity, stokes
E.A. Sealer	Methyl methacrylate/ ethyl acrylate (organic)	--	20.0	0.913	0.220
Cap Seal X	Silane (monomer) (organic)	8.0	0.005	0.830	<0.062
Chemtrete	Alkyl trialkoxy silane (organic)	5.6	0.7	0.835	<0.062
Hi-Density	Silicate (inorganic)	11.9	12.4	1.088	0.220
System 90-II					
Part A	Polymer (organic)	--	12.1	0.890	<0.062
Part B	Polymer (organic)	--	3.3	0.869	<0.062
Raylite B-12 Primer	Buterate (organic)	7.3	34.9	0.865	0.500
Raylite B-36 Top Coat	Buterate (organic)	7.5	12.5	0.809	<0.062
Penseal 50					
Part A	Epoxy (organic)	7.3	66.2	1.049	0.144
Part B		11.3	27.6	0.928	<0.062
Dekguard					
Primer	Alkoxy silane (organic)	5.8	6.9	0.791	<0.062
Top Coat	Methyl methacrylate/ ethyl acrylate (organic)	--	21.2	0.916	0.321
Preco Silane	Silane (organic)	6.0	10.9	0.815	<0.062
Thueco 161	Silane (organic)	6.7	6.9	0.718	0.27

PROPERTIES GOVERNING SEALANT PERFORMANCE

The Ministry occasionally uses surface sealants to prevent the penetration of concrete by deicing salt on non-traffic surfaces such as barrier walls, abutments and retaining walls. Surface sealants are not used on traffic surfaces such as pavements and bridge decks. For this reason, wear and skid resistance properties are not evaluated by this study. The following properties, as determined on concrete treated with a sealant, govern the performance of penetrating sealants:

i) penetration depth - sealants which penetrate the concrete susbstantially should be more durable.

ii) water absorption - to prevent saturation of the concrete, the sealant should not let water enter the concrete.

iii) moisture vapour permeability - the sealant should allow the concrete to breath to relieve water vapour pressure build up under the sealed surface.

iv) chloride penetration - the treated concrete surface should prevent the ingress of chloride into the concrete to prevent the corrosion of reinforcing steel.

v) salt scaling resistance - the treated concrete surface should be resistant to the destructive action of freezing and thawing in the presence of deicing salt and to thermal volume changes.

All the above properties with the possible exception of the penetration depth will govern the performance of a concrete coating. In addition, a concrete coating must form a good bond to the concrete surface. The salt scaling test also evaluates the quality of the bond.

TEST PROCEDURES

The test procedures used in the evaluation of the sealants were as follows:

Concrete Mix

All testing was carried out on a set of specimens made of concrete with a low air content and on a set of specimens made of air entrained concrete with a normal air content. Table B shows the mix proportions and the values for the slump and air content.

TABLE B CONCRETE MIX PROPORTIONS

Ingredient/Property	Low Air Content Concrete	Normal Air Content Concrete
Mix Proportions (Based on dry mass)		
Coarse aggregate, kg -dolomitic limestone 19.0 mm nom. max. size	48.7	48.7
Fine aggregate, kg -natural sand	33.2	35.1
Cement, Type 10, kg	16.0	16.0
Water, kg	8.0-8.4	7.9-8.4
Water reducing admixture, mL (WRDA)	70.4	70.4
Air entraining admixture, mL (DAREX AEA)	NIL	2.6-3.8
Fresh Concrete Tests		
Slump, mm	80 ± 10	80 ± 10
Air Content, %	3.5 ± 1.0	6.0 ± 1.0
Cement content, kg/m^3	355 ± 5	355 ± 5
Eff. W/C	0.466	0.436

The fine and coarse aggregate complied with the requirements of MTC Form 1002, the cement with Form 1301, water with Form 1302 and the admixtures with MTC Form 1303. The mix was made and the tests carried out in accordance with CSA Standard CAN3-A23.2.

Seven 150 x 150 x 50 mm and five 300 x 300 x 75 mm slabs were cast for each sealant. They were compacted by rodding in accordance with ASTM C 192-81. Each slab was cured moist for 14 d followed by 14 d curing at normal laboratory air conditions.

Application of the Sealants

Each sealant was applied by brushing it on to the concrete surface at the rate recommended by its manufacturer. Table C shows the application rate for each of the sealants tested.

TABLE C APPLICATION RATES

Sealant	Application Rate m^2/L per Coat	Number of Coats
E.A. Sealer	4.89	1
Cap Seal X	2.47	2
Chemtrete	3.69	1
Hi-Density	3.69	2
System 90-111	4.89	1st coat
	9.78	2nd coat
Raylite B-12	4.89	1
B-36	5.62	1
Penseal 50	3.36	2
Dekguard	2.47	1st coat
	4.89	2nd coat
Preco Silane	2.47	1
Thueco 161	2.47	1

Depth of Penetraton

After curing, the top surface of a 150 x 150 x 50 mm block was lightly sandblasted to remove the laitance. This was followed by the application of the sealant. The sealant (treated slab) was allowed to cure for 14 d at normal laboratory air conditions before it was cut into four 75 x 75 x 50 mm blocks. The blocks were then immersed in water for approximately one minute to delineate the depth of penetration. Two measurements were taken of the depth of penetration to the nearest 0.1 mm on each sawcut side of each block. The average of the 16 measurements was recorded as the depth of penetration.

Water Absorption

After curing, all sides of two 150 x 150 x 50 mm slabs were lightly sandblasted to remove the laitance and form oil. The slabs were then dried in an oven at 110 ± 5°C to a constant mass (A). This was followed by cooling to a normal room temperature and the application

of the sealant to all sides of each of the two blocks. After storage of the treated slabs at a normal laboratory air conditions for 14 d, the slabs were weighed (B) and then immersed in water for 48 h. They were removed from the water, surface dried with an absorbent cloth and then weighed (C). The absorption was calculated from the following formula.

$$\text{Absorption, \%} = \frac{C-B}{A} \times 100$$

Where
- A = mass of dry slab without the sealant to nearest 0.1 g
- B = mass of dry slab with the sealant to nearest 0.1 g
- C = mass of the block after water immersion to nearest 0.1 g

The reported absorption was the average of the two slabs.

Moisture Vapour Permeability

After curing, all sides of each of two 150 x 150 x 50 mm slabs were lightly sandblasted and then dried in an oven at 110 ± 5°C to a constant mass (A). After cooling the slabs to a normal room temperature, the slabs were immersed in distilled water for 48 h and then removed from the water and surface dried with an absorbant cloth (B). This was followed by the application of the sealant to all sides of the slabs. The treated slabs were stored for 14 d at normal laboratory air conditions and they were then placed in an oven at 110 ± 5°C until they reached a constant mass (D). The moisture loss was calculated from the following formula:

$$\text{Moisture loss, \%} = \frac{C - D}{B - A} \times 100$$

Where
- A = mass of sandblasted and dried slab to nearest 0.1 g
- B = mass of saturated surface dry slab to nearest 0.1 g
- C = B plus the mass of the sealant's solids content applied to the slab to nearest 0.1 g
- D = mass of treated slab after oven drying to nearest 0.1 g

The reported moisture loss (moisture vapour permeability) was the average of the two slabs.

Chloride Ion Penetration

After curing, the top surface of each of the two 300 x 300 x 75 mm slabs was lightly sandblasted to remove the laitance. This was followed by the application of the sealant to the top surface of each slab and storage of the slabs at normal laboratory air conditions for 14 d. The ponding with 3% sodium chloride solution and the coring

were in accordance with the Standard Method of Test for Resistance of Concrete to Chloride Ion Penetration, AASHTO Designation T 259-78 except that samples for chloride ion analysis were also obtained at the 25 mm to 38 mm depth, in addition to the 2-13 mm and 13-25 mm depths. The water soluble chloride ion contents were determined in accordance with MTC Test Method for Determination of Water Soluble Ion in Concrete, LS-411.

Salt Scaling Resistance

Two 300 x 300 x 75 mm slabs were prepared, sealant treated and cured in the same manner as for the chloride ion penetration test. The salt scaling test was as described in MTC Form 1351, Section 1351.07, Salt Scaling Resistance Test.

TEST RESULTS

Table D shows the results of the depth of penetration, water absorption and moisture vapour permeabililty tests.

TABLE D DEPTH OF PENETRATION, WATER ABSORPTION AND MOISTURE VAPOUR PERMEABILITY TEST RESULTS

SEALANT	LOW AIR CONTENT CONCRETE			NORMAL AIR CONTENT CONCRETE		
	Depth of Penetration, mm	Water Absorption, %	Moisture Vapour Permeability, %	Depth of Penetration, mm	Water Absorption, %	Moisture Vapour Permeability, %
Control (untreated)	--	5.03	100.0	--	4.52	99.7
E.A. Sealer	0	0.52	44.3	0	0.53	51.4
Cap Seal X	10.3	0.89	100.0	10.9	0.86	100.1
Chemtrete	13.3	0.80	117.0	19.0	0.82	115.4
Hi-Density	0	4.17	103.6	0	3.23	103.1
System 90-11	0	0.53	97.9	0	0.39	97.4
Raylite	0	0.56	96.3	0	0.52	95.6
Penseal 50	0	0.08	89.0	0	0.04	86.5
Dekguard	2.3	0.10	104.8	3.2	0.13	103.8
Preco Silane	5.9	0.71	87.5	5.3	0.62	102.8
Thueco 161	1.1	.94	96.7	0	0.71	96.5

Depth of Penetration

Only the silane type sealants penetrated the concretes. The penetrations produced by two of these sealants (Cap Seal X, Chemtrete) were significantly higher than those produced by the other silane sealants. One of these sealants (Thueco 161) penetrated only slightly (1.1 mm) the low air content concrete and no penetration was evident in the normal air content concrete. This test shows that Cap Seal X, Chemtrete, Dekguard and Preco Silane are true penetrants while the others are coatings.

Water Absorption

The specimens treated with each of the sealants with the exception of Hi-Density sealant, had a water absorption lower than 1.0%, significantly lower than that of the untreated control specimens (low air 5.03%, normal air 4.52%). The absorption of the specimens treated with Hi-Density sealant (silicate) was only approximately 1.0 percentage point lower than that of the untreated specimens. The manufacturers of this sealant explained that water must enter the concrete and react with the sealant to form an effective barrier. There must be sufficient water in the concrete for this reaction.

Moisture Vapour Permeability

The test was similar to that employed by the State of Oklahoma (3). Their criterium for the moisture loss is a minimum of 95.0%. Using this criterium, only two sealants - E.A. Sealer, Pen Seal 50 - did not allow sufficient moisture to leave the concretes. The Preco Silane specimens failed to comply with this criterium only in the low air content concrete. The specimens treated with Chemtrete, Dekguard and Hi-Density Sealants, and normal air content specimens treated with Preco Silane sealant showed higher moisture loss than they originally absorbed. This is probably due to the evaporation of not only the water but also some of the sealant. The Raylite specimens showed over 95% moisture loss but the coating formed bubbles while the specimens were in the oven and this indicated that the evaporation of the moisture was initially prevented by the coating.

Chloride Ion Penetration

Table E shows the test results. The amounts of chloride ion shown in Table E are after deduction of the background chloride ion content as determined on specimens from unponded slabs. Slabs treated with each of the test sealants, with the exception of Hi-Density sealant, were penetrated by a smaller amount of chloride ions than the amount determined in the control (untreated) slabs at the two top depths in the normal air content concrete and at the top depth in the low air content concrete. Practically, no choloride ions penetrated the third depth of either the low air content or the normal air content, treated and untreated concrete.

The slabs treated with the Hi-Density sealant contained significantly more chloride ions in the top depth than the control slabs. Some chloride ions was also found at the 25-38 mm depth in the slabs treated with this sealant. This low chloride ion content can be due to the assumption that the background chloride is the same at all levels of the cores.

The slabs treated with Dekguard (silane) and Penseal 50 (epoxy) absorbed practically no chloride ions. Cap-Seal X and Chemtrete did not perform as well as Dekguard. The slabs treated with either of the two sealants absorbed a lower amount of chloride ions into the top depth than that absorbed by the untreated slabs but the amount was significantly high. Preco Silane and System 90-11 perform better in this test than Chemtrete or Cap-Seal X.

TABLE E CHLORIDE ION PENETRATION TEST RESULTS

Sealant	Low Air Content Concrete			Normal Air Content Concrete		
	Average Water Soluble Chloride Ion Content at Indicated Depth, % by Mass of Concrete					
	2-13 mm	13-25 mm	25-38 mm	2-13 mm	13-25 mm	25-38 mm
Control (untreated)	0.2231	0.0856	0.0053	0.2490	0.0779	0.0039
E.A. Sealer	0.0836	0.0054	0.0000	0.1376	0.0282	0.0018
Cap Seal X	0.1431	0.0231	0.0000	0.1820	0.0194	0.0000
Chemtrete	0.2187	0.0165	0.0000	0.1512	0.0198	0.0000
Hi-Density	0.2640	0.0611	0.0074	0.5682	0.1147	0.0113
System 90-11	0.0352	0.0000	0.0000	0.0538	0.0095	0.0000
Raylite	0.1863	0.0100	0.0084	0.1158	0.0142	0.0014
Penseal 50	0.0000	0.0000	0.0000	0.0065	0.0000	0.0000
Dekguard	0.0032	0.0000	0.0000	0.0000	0.0000	0.0000
Preco Silane	0.0375	0.0011	0.0031	0.1087	0.0140	0.0001
Thueco 161	0.2076	0.0238	0.0000	0.2156	0.0411	0.0000

Salt Scaling Resistance

The test results are shown in Table F. The current acceptance guideline used by the Ministry for precast concrete (MTC Form 1351, 1352) is a maximum mass loss of 0.80 kg/m^2 at 50 cycles. The low air content control concrete considerably exceeded this limit while the normal air content concrete was far below this limit.

Each of the test sealants significantly improved the salt scaling resistance of the low air content concrete slabs, but Chemtrete, Hi-Density and Thueco 161 slabs produced a mass loss of 0.80, 0.87 and 1.16 kg/m^2, respectively. The highest mass loss produced by any of the other test sealants did not exceed 0.45 kg/m^3.

As expected, generally, the treated normal air content concrete slabs did not show better performance than the control slab. All, with the exception of the Chemtrete slabs, did not scale much and the differences could be due to the precision of the test. The Chemtrete slabs scaled 0.83 kg/m^3. Both the low air content and the normal air content concrete slabs treated with this sealant scaled at a relatively high rate.

TABLE F SALT SCALING TEST RESULTS

Sealant	Low Air Content Concrete	Normal Air Content Concrete
	Mass Loss at 50 Cycles, kg/m^2	
Control (untreated)	1.224	0.179
E.A. Sealer	0.146	0.130
Cap Seal X	0.317	0.293
Chemtrete	0.800	0.834
Hi-Density	0.874	0.266
System 90-11	0.394	0.169
Raylite	0.453	0.230
Penseal 50	0.104	0.146
Dekguard	0.206	0.275
Preco Silane	0.118	0.116
Thueco 161	1.157	0.196

GENERAL DISCUSSION

A surface sealant performs satisfactorily if it effectively seals the surface of the concrete to penetration by moisture and chloride. However, if the sealant seals also the moisture in the concrete and the concrete can not "breath", the vapour pressure buildup below the barrier formed by the sealant can damage the barrier.

Two situations are encountered in the field. One is where a sealant is applied only to one surface of the element and the concrete can

breath through the other surface. An example is a bridge deck barrier wall where a sealant is applied to the inner surface and the concrete can breath through the outer surface. In this situation, either a good quality coating or penetrant can be used. The other situation is where the concrete can breath only through the sealed surface such as columns, abutments and retaining walls. In this case only a good quality coating or penetrant that allows the concrete to breath through the sealed surface will perform satisfactorily.

The sealants tested can be divided into the two groups on the basis of the penetration depth test. If it is arbitrarily assumed that sealants that penetrate the concrete 2 mm or less are coatings and those penetrating the concrete more than 2 mm are penetrants, the sealants tested can be divided as follows:

Coatings	Penetrants
E.A. Sealer	Cap Seal X
Hi-Density	Chemtrete
Penseal 50	Dekguard
Raylite	Preco Silane
System 90-11	
Thueco 161	

The criterium for water absorption of maximum 1.0% by mass of concrete is assumed to be a reasonable requirement for the sealants. Hi-Density does not meet the requirement.

The State of Oklahoma, which developed the moisture vapour permeability test used in this project, requires a minimum moisture vapour loss of 95.0%. Using this criterium, only E.A. Sealer and Penseal 50 will not allow the concrete to breath sufficiently. Preco Silane is borderline in meeting the requirements.

The water soluble chloride ion corrosion threshold value is generally considered to be 0.02% by mass of concrete. If this value is used as an acceptance criterium at the 13-25 mm depth, Hi-Density and Thueco 161 don't comply with the requirement and E.A. Sealer as well as Cap Seal X are considered borderline.

The salt scaling acceptance guideline for precast concrete (MTC Form 1351 and 1352) has been used to delineate the sealants with satisfactory performance from those of unsatisfactory performance with an emphasis placed on the concrete with low air content. Chemtrete, Hi-Density and Thueco 161 do not comply with the requirements.

The relative performance of the sealants tested in each of the tests is shown in Table G. Table G also delineates the sealants with acceptable and unacceptable performance in each of the tests.

TABLE G RELATIVE PERFORMANCE OF THE SEALANTS

LOW AIR CONTENT CONCRETE					NORMAL AIR CONTENT CONCRETE				
Penetration Depth	Water Absorption	Moisture Vapour Permeability	Chloride Ion Penetration	Salt Scaling Resistance	Penetration Depth	Water Absorption	Moisture Vapour Permeability	Chloride Ion Penetration	Salt Scaling Resistance
Chemtrete	Penseal 50	Chemtrete	Penseal 50	Penseal 50	Chemtrete	Penseal 50	Chemtrete	Penseal 50	Preco Silane
Cap Seal X	Dekguard	Dekguard	Dekguard	Preco Silane	Cap Seal X	Dekguard	Dekguard	Dekguard	E.A. Sealer
Preco Silane	E.A. Sealer	Hi-Density	System 90-11	E.A. Sealer	Preco Silane	System 90-11	Hi-Density	System 90-11	Penseal 50
Dekguard	System 90-11	Cap Seal X	Preco Silane	Dekguard	Dekguard	Raylite	Preco Silane	Preco Silane	System 90-11
Thueco 161	Raylite	Control	E.A. Sealer	Cap Seal X	E.A. Sealer	E.A. Sealer	Cap Seal X	Raylite	Control
E.A. Sealer	Preco Silane	System 90-11	Raylite	System 90-11	Hi-Density	Preco Silane	Control	Cap Seal X	Thueco 161
Hi-Density	Chemtrete	Thueco 161	Chemtrete	Raylite	System 90-11	Thueco 161	System 90-11	Chemtrete	Raylite
System 90-11	Cap Seal X	Raylite	Cap Seal X	Chemtrete	Raylite	Chemtrete	Thueco 161	E.A. Sealer	Hi-Density
Raylite	Thueco 161	Penseal 50	Thueco 161	Hi-Density	Thueco 161	Cap Seal X	Raylite	Thueco 161	Dekguard
Penseal 50	Hi-Density	Preco Silane	Hi-Density	Thueco 161	Penseal 50	Hi-Density	Penseal 50	Control	Cap Seal X
	Control	E.A. Sealer	Control	Control		Control	E.A. Sealer	Hi-Density	Chemtrete

NOTE: The best performer is at the top, the worst at the bottom of the list for each of the tests. The horizontal lines divide the acceptable from unacceptable performers.

CONCLUSIONS

On the basis of the tests described in this report, the following conclulsions are drawn:

i) Four of the sealants tested - Cap Seal X, Chemtrete, Dekguard and Preco Silane are classified as penetrants. All of them with the exception of Chemtrete comply with all the requirements including the moisture vapour permeability. Chemtrete fails the salt scaling resistance requirement.

ii) Six of the sealants tested - E.A. Sealer, Hi-Density, Penseal 50, Raylite, System 90-11 and Thueco 161 are classified as coatings. Raylite and System 90-11 comply with all the requirements including the moisture vapour permeability. However, Raylite treated concrete forms blisters when exposed to elevated temperature and this damages the treatment. E.A. Sealer and Penseal 50 fail only the requirement for moisture vapour permeability. Hi-Density and Thueco 161 fail the requirements for chloride ion penetration and salt scaling resistance. Hi-Density also failed the water absorption requirement.

RECOMMENDATIONS

The following sealants performed well in the laboratory and have good potential for use on structures.

i) penetrants - Cap Seal X, Dekguard and Preco Silane for all applications.

ii) coatings - System 90-11 for all applications, and E.A. Sealer and Penseal 50 only where the concrete will be able to breath through other than the sealed surface.

The list of the above sealants together with the addresses of their suppliers is attached as **Appendix A.**

Coatings and penetrants are very expensive. They should be used only when there is a reasonably high probability that the concrete will scale without some protection or chlorides will penetrate the concrete at a faster than normal rate due to insufficient cover and cause corrosion of the reinforcing bars. Instances where sealants can be used are:

i) When concrete will not be sufficiently cured to reach a strength adequate for freeze-thaw resistance.

ii) When the air void system of the concrete is deficient.

iii) When the strength of the concrete is inadequate.

iv) When the concrete has scaled prematurely and the scaling will continue to worsen.

v) When there is less than 40 mm concrete cover to the reinforcing steel.

vi) When there is a very severe exposure such as that of concrete surfaces under open bridge deck expansion joints.

Sealants should not normally be applied to adequately cured and air entrained concrete that meets the strength requirements and that has sufficient cover to the steel. This concrete is already adequately durable and it does not normally require any special protective measures.

The surfaces to receive the sealant must be lightly sandblasted and the sealant should be applied in accordance with the manufacturer's directions.

REFERENCES

1. Ryell, J. and Chojnacki, B., "Laboratory and Field Tests on Concrete Sealing Compounds" D.H.O. Report No. RR150, December 1969.

2. Pfeifer, D.W. and Scali, M.J., "Concrete Sealers for Protection of Bridge Structures", T.R.B. Report No. 244, December 1981.

3. Oklahoma Department of Transportation, "Test for Depth of Penetration of Concrete by Penetrating Water Repellent Treatment Solutions", OHD L-34, 8-23-82.

4. Oklahoma Department of Transportation, "Moisture Sealer Absorption Test".

5. Oklahoma Department of Transportation, "Test for Moisture Vapour Permeability of Treated Concrete", OHD L-35, Revised 2-24-83.

APPENDIX A LIST OF SEALANTS WHICH PERFORMED WELL IN LABORATORY TESTS

SEALANTS

PENETRANTS

CAP-SEAL X	Cappar Limited 39 Selby Road Brampton, Ontario L6W 1K5 (416) 453-5280
DEKGUARD PRECO-SILANE	Fosroc Construction Chemicals Foseco Canada Inc. 361 Speedvale Avenue W. Guelph, Ontario (519) 822-6440

COATINGS*

SYSTEM 90-11	DRE Industries 69 Westmore Drive, Unit 3 Rexdale, Ontario M9V 3Y7 (416) 746-7763
E.A. SEALER*	Fosroc Construction Chemicals Foseco Canada Inc. 361 Speedvale Avenue W. Guelph, Ontario (519) 822-6440
PENSEAL 50*	American Metaseal Company 509 Washington Avenue Carlstadt, N.J. 07072 (201) 933-1720

***For use only where the concrete will be able to breath through other than the sealed surface**